Activity 4: Locating Vent Fields Using CTD Data

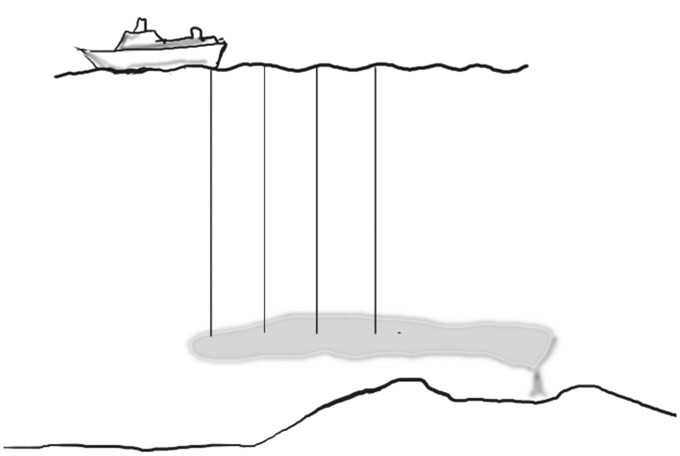
Overview:

This lesson applies the concepts from the previous lessons to the task of actually locating vent regions by remotely collecting water temperature and density data from the ocean floor. In this activity, students simulate the task of locating hydrothermal vents on the Juan de Fuca ridge. Students examine a series of actual temperature and density graphs and compare them to known ambient ocean floor conditions. They look for clues that something different is happening below. When conditions change, students examine the differences, develop explanations for the differences and note the location so *Alvin* can go down and verify the presence of vents.

Background:

One instrument that scientists use to locate hydrothermal vent plumes is the CTD (Conductivity- Temperature - Depth) instrument. There are two methods used to study hydrothermal plumes with this instrument from the ship:

A) Lowering a CTD in a series of vertical "casts."



Essential Concept:

HTVs can be located by looking for variations in Conductivity, Temperature and Density.

Learning Objectives:

Students will be able to:

- explain how data from CTD sensors are used to locate hydrothermal vents.
- read data from CTD sensors and predict when an HTV is present.
- describe how a hydrothermal vent works.
- make observations & inferences from graphs.

National Standards:

- Unifying concepts and processes:
  - Evidence, models and explanation
- Physical Science
  - Properties and changes of properties in matter
  - Transfer of energy
- Earth and Space Science:
  - Structure of the earth system

Materials

- CTD Graphs
- Set up 6 "Waypoint" stations using the graphs

Activity 4 (cont.):

Resources:

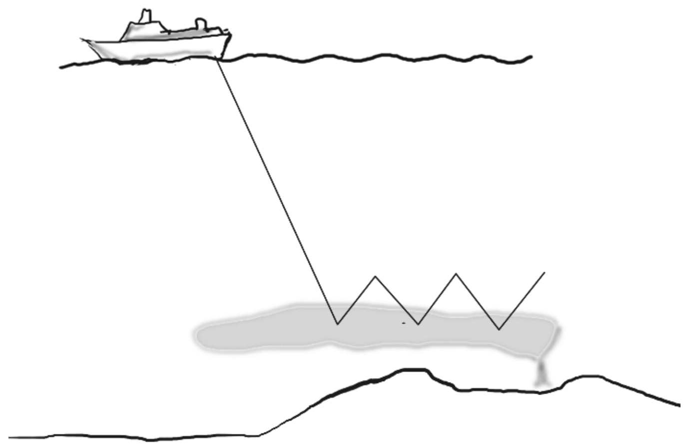
Revel
To follow the REVEL voyage to the Juan de Fuca plate on which science teacher Cindy Maldanado participated in collecting the data the students will be using check out September 5, 6 and 7 at
http://www.ocean.washington.edu/outreach/revel00/sublogbooktext.html

Dive and Discover
CTD
For a great real life explanation about what CTD sensor crews do visit the Hydrothermal Vent Prospecting Team page on Hot topics [Expedition 4-7: Daily Update: Hot Topics: Hydrothermal Vent Prospecting Team]

MAPR
MAPRs are instruments that collect similar information and help to locate HTVs more on MAPRs can be found in Hot Topics as well [Expedition 3-7:Daily Update : Hot Topics: Finding Telltale Hydrothermal Plumes With MAPRs (Miniature Autonomous Plume Recorders]
http://www.divediscover.whoi.edu/

American Museum of Natural History: Resources for Learning
This site offers an opportunity to do a simulated search for a hydrothermal vent.
http://www.amnh.org/education/resources/card_frame.php?rid=756&rurlid=733

B) Raising and lowering the CTD while slowly towing it from the ship, called a "Tow-Yo."



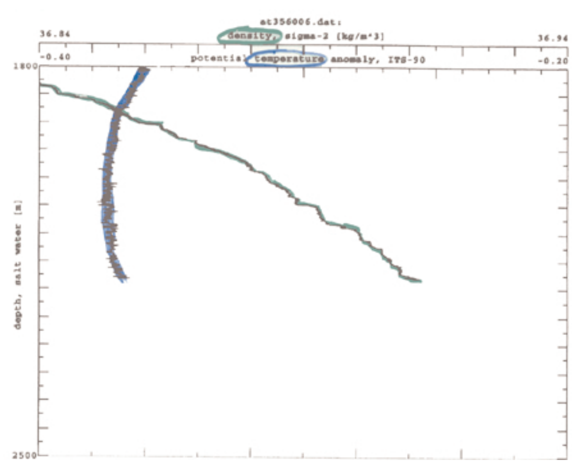
Information about the characteristics of the seawater is sent to the ship's computer lab through cables where scientists analyze it to determine if in fact a hydrothermal vent site is below. They capture water samples for onboard analysis and when the right pieces of the puzzle come together, a dive plan is prepared for Alvin.

Development of Lesson (Steps):

1. Explain to students that we will simulate actual events of a cruise to the Juan de Fuca ridge and the search for new hydrothermal vents. You may want to point out the location on the Ridge Multibeam Synthesis Project World Map (cruise 2, activity 2). It is the area outlined by the green box labeled Northeast Pacific Ridge.

2. Arrange students in groups around the room forming six stations that will serve as "waypoints" or spots where the ship does the "Tow-Yo" casts.

3. Display Graph 1. Explain that the graph indicates temperature and density and is used to scan for anomalies.



- The blue line shows temperature anomalies (i.e. irregularities). In ocean water where no plume is present, we expect the blue line to extend

Activity 4 (cont.):

down the graph with only slight squiggles indicating no significant temperature changes or anomalies. If the line spikes, indicating an increase in temperature, we are near a plume.

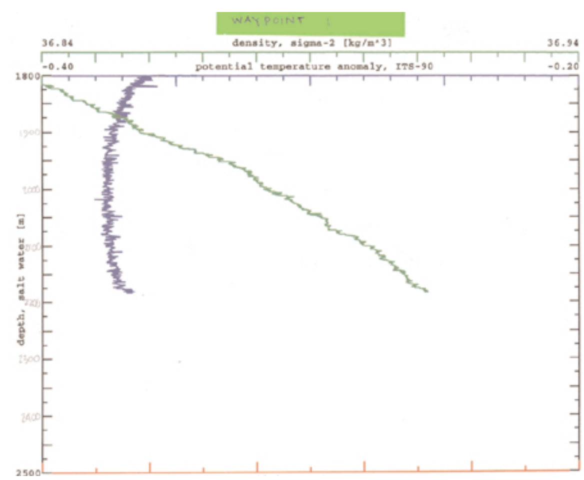
- The green line shows density, which is a measure of salinity and temperature combined. In oceans, the denser (saltier) water is at the bottom. In ocean water where no plume is present, we expect this density line to move from left to right across the graph signifying an increase in density with depth. HTV fluids are less dense than surrounding seawater and therefore rise, until they reach a point in the water column where the surrounding seawater density is the same. This point is called the neutrally buoyant point. If the density line inverts (i.e. changes direction), we have hit a pocket of water that is less dense and is likely a plume of rising vent fluids.

When both of these trends are broken, we have evidence of hydrothermal vent activity.

3. Distribute graphs for waypoints 1-6 to the six stations, instructing students not to reveal them until we reach that waypoint with our ship.

4. Direct the following enactment of the ship's night activities with the students:

Since we are on a ship that never sleeps and our days are busy with *Alvin* dives, we spend our nights in search of new hydrothermal vent sites. The captain moves the ship to waypoint 1 and we lower the CTD package over the side of the ship and down towards the seafloor.

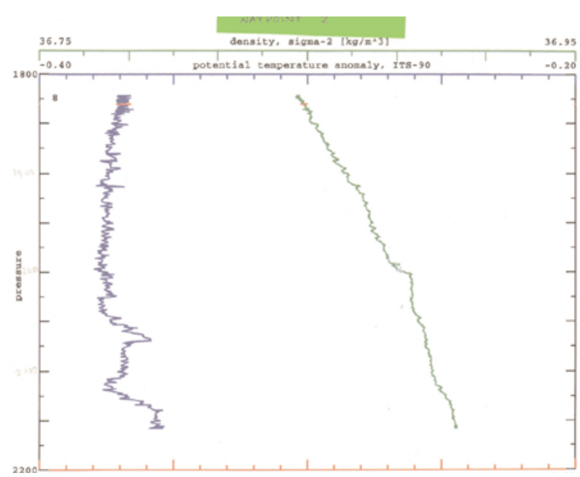


WAYPOINT 1

Have students at waypoint 1 reveal their graph and discuss whether or not there is evidence of hydrothermal vent activity.

(*Nothing is happening here. The temperature and density lines are as expected without the presence of venting.*)

Raise the CTD to 1800 m and instruct the ship's captain to continue to waypoint 2.



WAYPOINT 2

Lower the CTD to 2150 m and analyze the graph as the CTD descends.

Have students at waypoint 2 reveal their graph and discuss whether or not there is evidence of hydrothermal vent activity.

(*There is a jump in the temperature graph indicating that some warm water has been detected, but the density graph shows nothing unexpected.*)

Again raise the CTD to 1800 m and instruct the ship's captain to move on to waypoint 3.

Activity 4 (cont.):

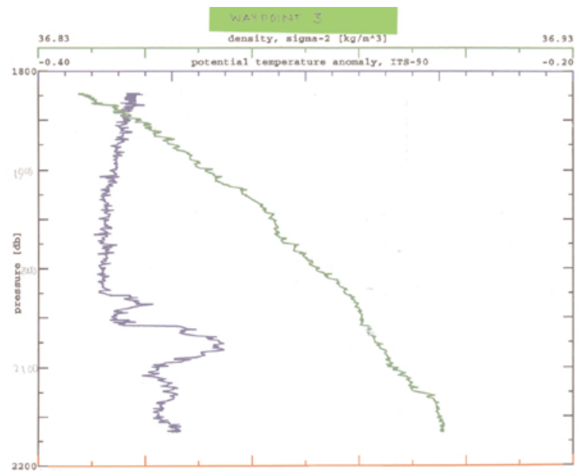
WAYPOINT 3

Lower the CTD to 2150 m and analyze the graph as the CTD descends.

Have students at waypoint 3 reveal their graph and discuss whether or not there is evidence of hydrothermal vent activity.

(*Again the temperature indicates the presence of warmer water, this time more pronounced than at waypoint 2. The graph for density remains normal, unfortunately. We might be near a plume but there is no rising fluid associated with the vertical portion of a vent plume. We click the computer's mouse onboard ship and collect a sample of water at this interesting site.*)

Raise the CTD to 1800 m and instruct the ship's captain to continue to waypoint 4.



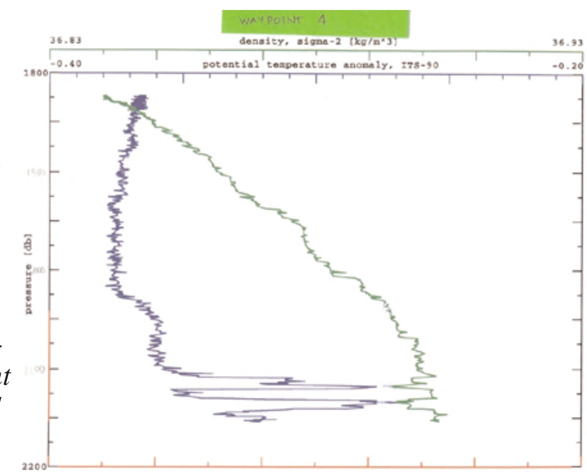
WAYPOINT 4

Lower the CTD to 2150 m and analyze the graph as the CTD descends.

Have students at waypoint 4 reveal their graph and discuss whether or not there is evidence of hydrothermal vent activity.

(*Not only is there a significant temperature change, the density curve has reversed—instead of an increase in density there is suddenly a decrease in density. The extremely hot fluid of a vent site has very low density and overpowers the density reading of the surrounding seawater. This is promising evidence of hydrothermal vent activity! Water samples are collected and coordinates are recorded for a possible Alvin dive.*)

With encouraged hearts and renewed strength, raise the CTD to 1800 m and instruct the ship's captain to steam to waypoint 5.



WAYPOINT 5

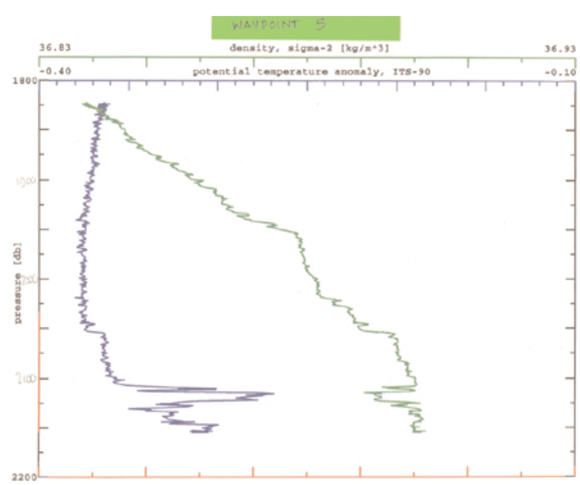
Lower the CTD to 2150 m and analyze the graph as the CTD descends.

Have students at waypoint 5 reveal their graph and discuss whether or not there is evidence of hydrothermal vent activity.

WAYPOINT 5(Graph)

(*This looks promising as well! The temperature graph spikes and there is a reversal in density. Water samples are collected again. If other evidence comes in – presence of vent chemicals such as iron, manganese, methane, methane, and hydrogen in the water samples – that Alvin dive is just around the corner!*)

The night is not over yet so we raise the CTD to 1800 m and instruct the ship's captain to travel to waypoint 6.



Activity 4 (cont.):

WAYPOINT 6

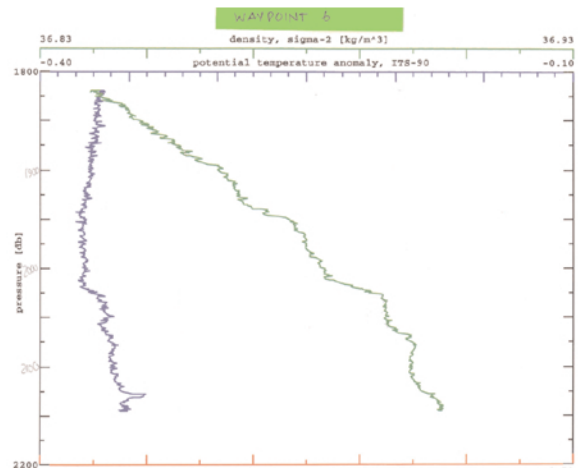
Lower the CTD to 2150 m and analyze the graph as the CTD descends.

Have students at waypoint 6 reveal their graph and discuss whether or not there is evidence of hydrothermal vent activity.

(*There is a tiny temperature anomaly but nothing to get excited about as the density graph moves along as expected.*)

Having found two promising sites, we call it a night!

(Graphs are from REVEL 2000 Cruise 2 (September 1 – 20, 2000). Marv Lilley of University of Washington's School of Oceanography was in charge of CTD activities. Brian Kristall, also at Univ. of Washington helped decipher the graphs.)



Discussion Questions:

1. You have an opportunity to take Alvin for a dive on just one site. Where will you go and what evidence gained through CTD operations supports your choice? (*we'd recommend going for waypoint 4 or 5 since both the temperature spiked and the density inverted.*)

2. What other evidence would you like to support your decision? (*water samples indicating the presence of minerals common in vent fluids*)

3. What do you expect to see when you reach the seafloor? (*a Hydrothermal Vent*)

4. Why do we need to measure both temperature and density? (*The vent plume will rise until it reaches neutral buoyancy at which point it will level out and move horizontally. This portion of the plume is still hot, but is no longer rising. The CTD instrument would register a temperature anomaly but no density anomaly, indicating that the instrument is not directly OVER the vent but away from it at some distance. We're near but we need to keep searching*.)

Extensions:

Try your hand at using the CTD to find a hydrothermal vent on the Juan de Fuca Ridge.

http://www.amnh.org/education/resources/card_index.php?rid=756